The Research of Control Strategy for Double Motor Electric Vehicle

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Abstract: The control strategy of double motor electric vehicle was formulated. Firstly, the battery energy management strategy was constructed by using of instantaneous optimization algorithm for maximum efficiency. Secondly, the all-wheel drive control strategy was built includes dynamic distribution strategy, stability distribution strategy, anti-skid distribution strategy and economic distribution strategy. Lastly, the simulation evaluation of dynamic performance and economic performance were conducted based on the MATLAB/SIMULINK platform. The results indicate that four-wheel drive has better dynamic performance and less economic performance. The front motor or rear motor drive only has better economic performance.

1. Introduction

The electric vehicle (EV) can obtain zero emission and save use cost, which get attention deeply by different countries, car enterprise and scientific research structure.

An optimization strategy of acceleration torque control [1] for pure electric vehicle is proposed based on fuzzy control, A dual-objective optimization method based on MOGA-II genetic algorithm [2] is proposed for the ratio of power train to be matched reasonably to the drive motor of pure electric vehicle. A pure electric car ownership system dynamics model was established, and the trend of the development of pure electric vehicles was simulated [3]. The torque optimal control [4] problem of pure electric vehicle was studied.

In this paper, the battery energy management strategy is firstly constructed by using of instantaneous optimization algorithm for increasing driving mileage. Secondly, the four-wheel drive control strategy is obtained based on the dynamic target. Lastly, the simulation results are analyzed for checking dynamic performance and economic performance in different driving cycle based on MATLAB -SIMULINK platform.

The paper is organized as follows. In the next section, we propose the powertrain structure of double motor electric vehicle that we research in this paper, and some parameters are given. In Section 3, the battery energy management strategy and all-wheel drive control strategy is built. Then we finish the dynamic and economic simulation analysis based on MATLAB -SIMULINK platform. Finally, we conclude our paper in section 4.

2. Powertrain structure and parameters

The powertrain system is composed of front motor, rear motor, and battery. The vehicle structure of PHEV is shown in Fig.1. Parameter values and specifications for the PHEV model are provided in Table 1.

HCU (Hybrid Control Unit) can control front motor and rear motor to realize the all-wheel drive (AWD) mode, front- wheel drive (FWD) mode, and rear-wheel drive (RWD) mode.

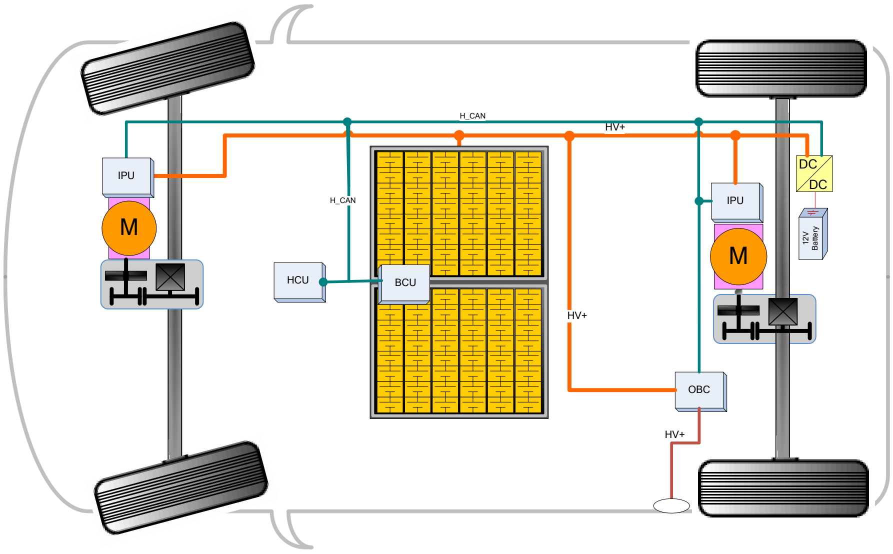

Fig1 Structure of EV drivetrain

Table 1 The powertrain parameters of EV

Component	Characteristic	Data/Values
Vehicle	Mass	1680kg
	Frontal area	2.28 m^2
	Aerodynamic drag coefficient	0.357
	Wheel radius	0.352m
	Rolling resistance coefficient	0.0083
Front Motor	Maximum power	60 kW
	Maximum torque	137 Nm
	Maximum speed	12000 rpm
Rear Motor	Maximum power	50 kW
	Maximum torque	200 Nm
	Maximum speed	15000 rpm
Battery	Energy storage	≥45 kW·h
	Rated voltage	345 V

3. Vehicle control strategy

3.1 Battery Energy Management Strategy

The idea of battery energy management strategy makes full use of battery energy for economy. The instantaneous optimization target function is described in equation (1).

$$J = \max(\frac{P_{WD}}{P_b(U_b I_b)}) = \max(\frac{P_{FM}\eta_{FM}(T_{FM}N_{FM}) + P_{RM}\eta_{RM}(T_{RM}N_{RM})}{P_b(U_b I_b)}) \quad (1)$$

where, P_{WD} is the driver wheel demand power, P_b is the battery consumption power , U_b is the battery voltage, I_b is the battery current, P_{FM} is the front motor power , η_{FM} is the front motor efficiency, T_{FM} is the front motor torque, N_{FM} is the front motor speed, P_{RM} is the rear motor power , η_{RM} is the rear motor efficiency, T_{RM} is the rear motor torque, N_{RM} is the rear motor speed.

In order to understand the four-wheel drive vehicle energy management strategy better, the front axle torque distribution coefficient is described in equation (2)

$$C_{fa} = \frac{T_{FM}}{T_{FM} + T_{RM}} \quad (2)$$

The front axle torque distribution coefficient MAP can be calculated separately by using equation (1), are shown in Fig. 2.

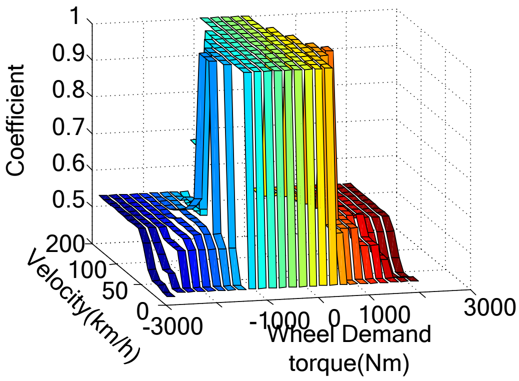

Fig2 Front axle torque distribution coefficient MAP

3.2 AWD control strategy

The idea of all-wheel drive control strategy includes dynamic distribution strategy, stability distribution strategy, anti-skid distribution strategy and economic distribution strategy.

The economic distribution strategy is referred to in Section 3.1. The dynamic distribution strategy is described in equation (3)

$$C_{Dy} = \frac{T_{FMMax}}{T_{FMMax} + T_{RMMax}} \tag{3}$$

Where, T_{FMMax} is the front motor maximum torque, T_{RMMax} is the rear motor maximum torque. The stability distribution strategy mainly considers the vehicle speed and the steering wheel angle. The vehicle speed is higher, the bigger the front axle distribution coefficient. The steering wheel angle is bigger, the bigger the front axle distribution coefficient. The front axle torque distribution coefficient MAP is shown in Fig. 3.

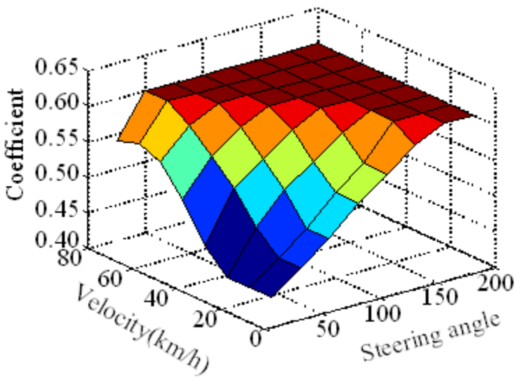

Fig3 Stability distribution coefficient MAP

The main idea of the anti-skid distribution strategy is that the drive torque is shifted back to the rear axle when the front wheel is slipping. When the rear wheel is slipping, the drive torque is shifted to front axle. The anti-skid distribution strategy has highest priority.

3.3 Dynamic performance and driving mileage analysis

The dynamic performance indicators contain maximum velocity, acceleration time and maximum gradeability. The results are shown in Table 2.

Tab 2 The simulation result of dynamic performances

Dynamic indicators	Simulation results
0～50km/h acceleration time（s）	5.759
0～80km/h acceleration time（s）	8.359
Maximum gradeability （%）	30.54%
Maximum velocity （km/h）	118

It can be seen that the acceleration time from 0 to 50 kilometers per hour is 5.759 seconds. The acceleration time from 0 to 80 kilometers per hour is 8.359 seconds. The maximum gradeability is 30.54 percent. The maximum velocity is 118 kilometers per hour.

The driving mileage of the double motor vehicle is shown in Table 3.

Tab 3 The simulation result of driving mileage

Driving Cycle Condition	Front axle drive	Rear axle drive	All-wheel drive
NEDC	54.0km	52.1km	50.2km
WLTC	47.9 km	45.2km	42.1km

It can be seen that the longest mileage is the front wheel drive, and the shortest mileage is the four wheel drive. The mileage of WLTC is shorter than the NEDC, because the WLTC contains more transient conditions.

4. Conclusions

In the paper, the battery energy management strategy is proposed by the use of instantaneous optimization algorithm for optimal driving efficiency. The all wheel drive control strategy is put forward. The simulation results show that four-wheel drive has better dynamic performance and less economic performance.

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